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ABSTRACT

This study examined changes in infants' performance in detecting tones as a funtion of time. Stimuli were presented in blocks of fixed frequency and intensity, rather than in random order. The findings of earlier studies that an observer can reliably tell from a 1-month-old's behavior when a pure tone is being presented, and that reinforcement of infant responses to tones improves the observer's performance, were replicated. Results showed that observers performed as well in the fixed stimulus condition as in the random order condition. However, there were frequency-specific changes in performance over the course of a test session. References to three articles and numerous graphs are included. (BC)

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Application of an Observer-based Procedure to the Assessment of Auditory Sensitivity in 1-month old Infants

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Abstract

We have previously reported that an observer can reliably tell from a 1-month-old's behavior when a pure tone is being presented, that confidence ratings can be used to estimate bias-free measures of sensitivity in this age group, and that reinforcing infant responses to tones improves the observer's performance. The present study replicated these findings presenting stimuli in blocks of fixed frequency and intensity, rather than in random order. The results showed that observers performed about as well in the fixed stimulus condition as in the random order condition. However, frequency-specific changes in performance over the course of a test session did occur. The implications of these findings for the assessment of infant auditory sensitivity are discussed.

Background

At least two laboratories have applied an observer-based approach to assessing the auditory sensitivity of newborn to 3-month-old infants (Trehub et al., 1991; Werner & Gillenwater, 1990). Teller and colleagues (1974) originally developed this approach to doing infant visual psychophysics. In an observer-based procedure, the measure of sensitivity is not based directly on the presence or absence of a specific response from the infant. Rather the measure of sensitivity is based on whether an observer who watches the baby can tell from the infant's behavior that a sound has occurred.

Variables such as the type of measure used and whether the infant's responses to sound are reinforced have turned out to have important influences on the results obtained with these young subjects. The present study addressed an additional methodological issue. In order to get the best estimate of any observer's capacity, it is typical to give the observer practice in the task before data are collected. Although one cannot give infants extensive practice in listening, it is common practice to establish that they demonstrate at least a rudimentary understanding of what is required. However, training can be very time consuming. Moreover, young infants are typically in a stable, alert state only for short periods of time. Thus, it is possible that by the time an infant reaches training criterion, any additional information obtained would not represent the infant's best performance. The purpose of this study was to examine changes in 2- to 4-week-olds' performance in detecting tones as a function of time.

Methods

Subjects

-72 infants tested; 32 completed 16 test trials.
- Mean age 27 days, sd = 3.4
- Included infants had uncomplicated medical histories and no risk factors for hearing loss.

Stimuli

- Pure tones at 500, 1000, or 4000 Hz
- Sound pressure level of 25, 35, 45, or 55 dB
- Duration 500 ms with 10-ms rise/fall
- 6 repetitions with 500 ms between tones on each trial
- Presented through Etymotic insert earphone

Procedure

Major features of the procedure

Observer begins a trial when infant is "ready"
A signal (6 repetitions of tone) or no-signal (no tone) trial is presented.
Observer responds "1" (certain that no signal occurred) to "4" (certain that a signal occurred)
Observer receives feedback after each trial
Infant hears a recording of women reading from children's books if the observer is correct on a signal trial.
Two phases of the experiment:

Training: Signal trials occurred with probability of 0.50.
Tones presented at 55 to 75 dB SPL
Stopping criterion: 4 of last 5 signals and 4 of last 5 no-signals correct

Testing: Signal trials occurred with probability of 0.50.
Tones presented at 25, 35, 45, or 55 dB SPL
Intensity and frequency fixed
Stopping criterion: 16 trials completed or baby in no state to continue

Results

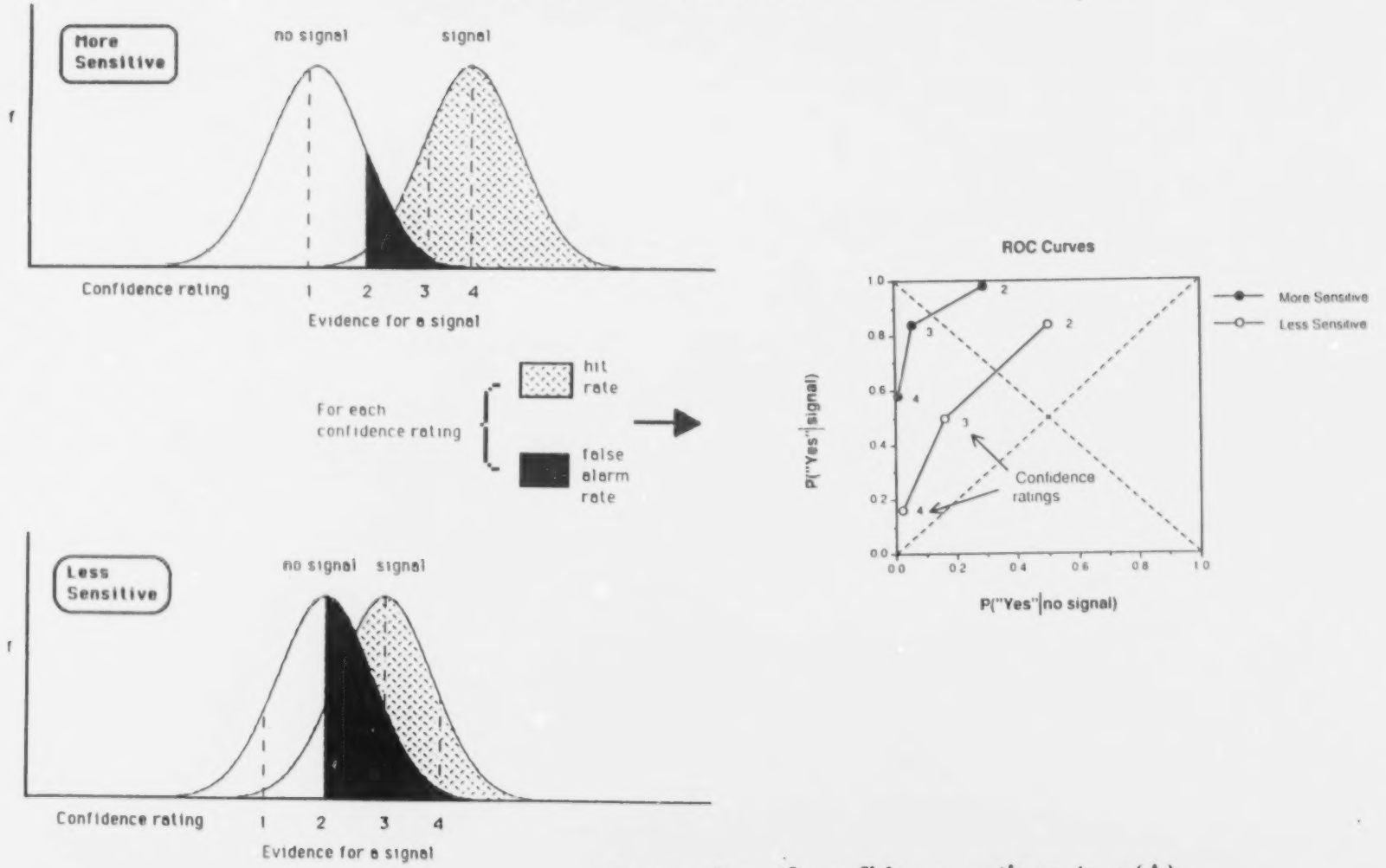
An ROC curve was constructed for each infant at each level at which 16 test trials were completed. The figure below shows some examples of ROC curves from individual infants (left panel). The area under each curve, p(A), was calculated. p(A) is plotted as a function of level for the same infants in the right panel of the figure.

p(A) was also calculated based on the first 8 and on the second 8 of the 16 test trials. As the same general trends were seen at all sound pressure levels, average p(A) for all levels at each frequency is shown in the figure below. Notice that average p(A) grows significantly poorer from the first 8 to the second 8 trials at 500 Hz, but that p(A) does not change at 1000 Hz and actually continues to improve between the first 8 and second 8 test trials at 4000 Hz!

This difference in the amount and direction of change in performance during testing is correlated with the number of trials required to meet criterion in training, as shown in the figure below. Significantly more trials were required to meet criterion at 4000 Hz than at the other frequencies.

These results suggest that the training procedure is not accomplishing what we had hoped with these young infants, and led us to make modifications in the procedure as shown in the next panel.

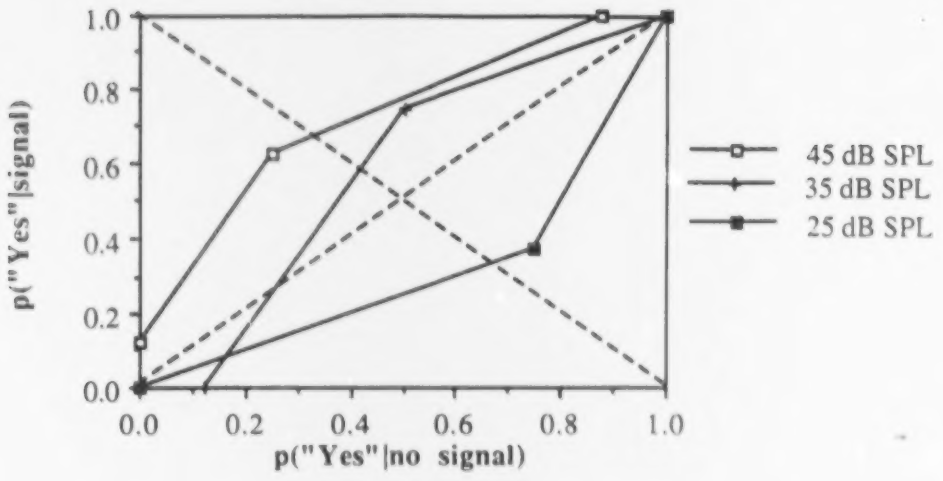
Figure 1. Schematic of conversion of confidence ratings to receiver operating characteristic curves.



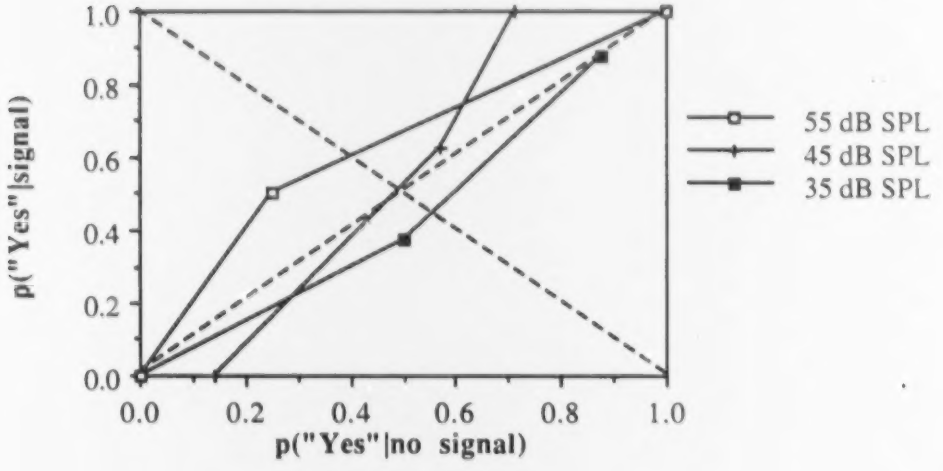
Conversion of confidence ratings to p(A)

Figure 1 illustrates the logic behind the use of confidence ratings to get a bias-free estimate of sensitivity. The measure used was the area under the curves plotted on the right side of the figure, referred to as p(A). The measure ranges from 0 to 1.0, with 0.5 representing chance performance and 1.0 representing perfect performance.

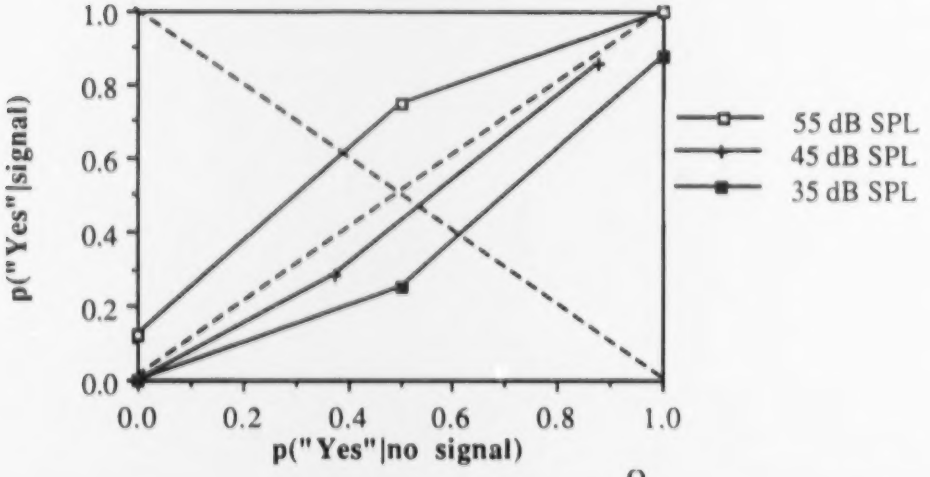
Subject 9: 500 Hz

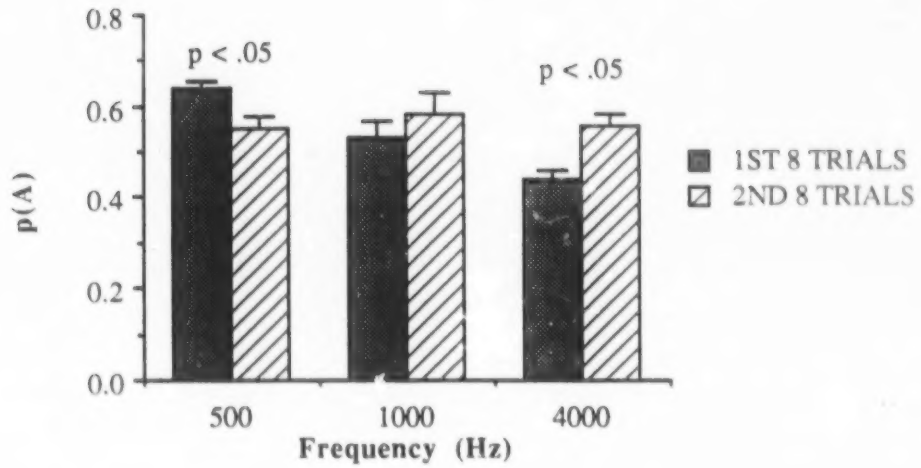


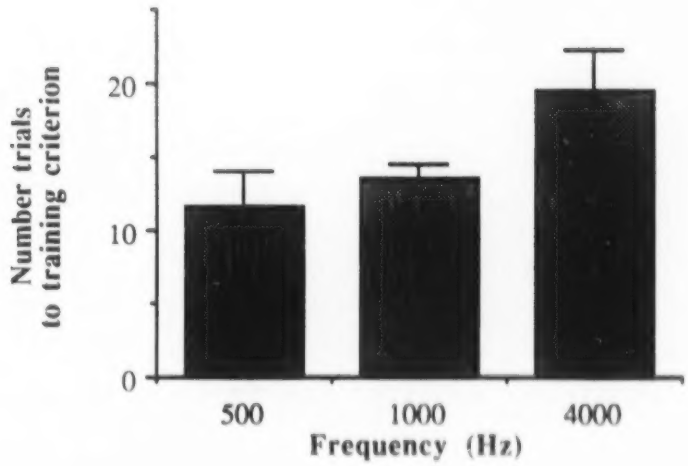
Subject 64: 1000 Hz



Subject 71: 4000 Hz




0.8
0.6
0.4
0.2
0.0
p(A)
p < .05
p < .05
1ST 8 TRIALS
2ND 8 TRIALS
500
1000
4000
Frequency (Hz)


Number trials
to training criterion
20
10
0
500
1000
4000
Frequency (Hz)

Preliminary Results Using Modified Procedure

The Changes

- No training phase per se
- Testing proceeds in 8 trial blocks; observer receives feedback re: p(A) at conclusion of each block
- Testing continues until
  - performance peaks
    - OR
  - performance exceeds a p(A) of 0.83 in a single block
    - OR
  - infant's state precludes further testing
- Best performance at a sound pressure level is taken as estimate of sensitivity

Subjects

15 infants tested to date; 10 have completed testing at 3 levels
Average age 25 days, sd = 3.1

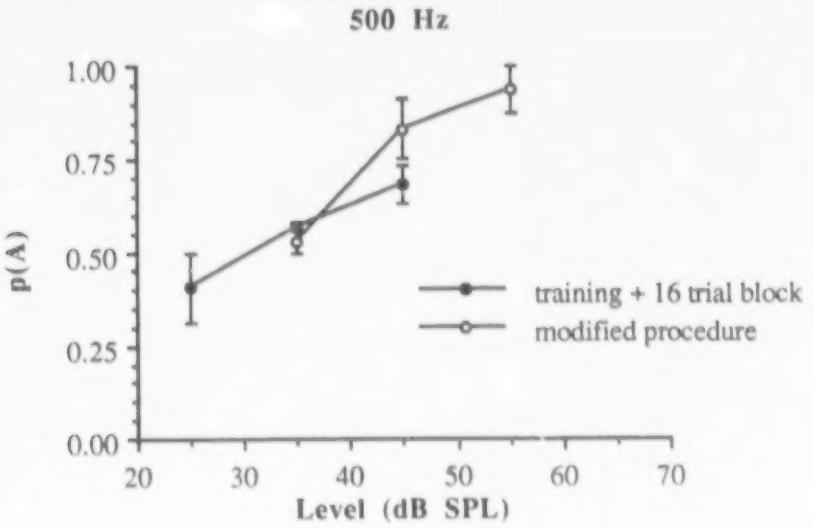
Comparison of modified method to original method

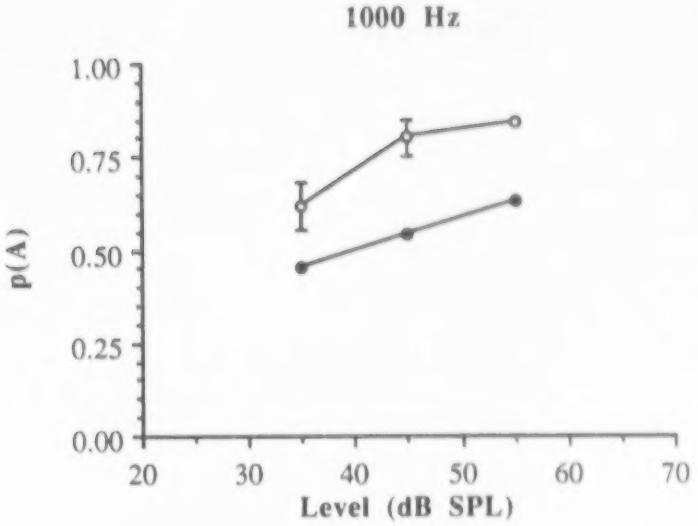
Examples of individual results

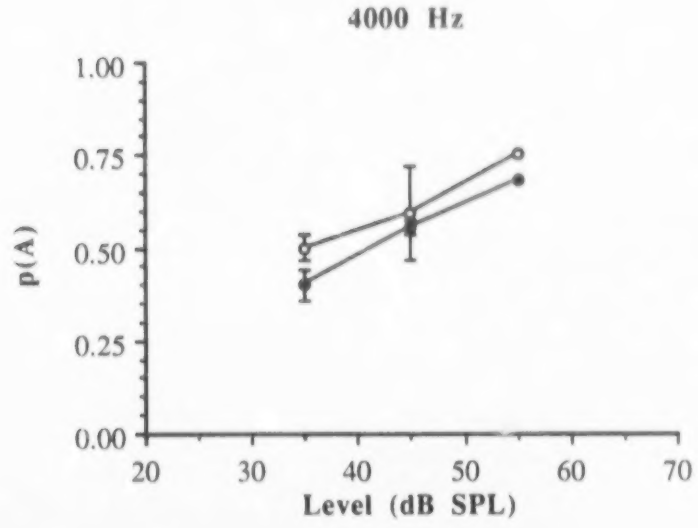
ROC curves

Psychometric functions

Comparison of modified method to original method

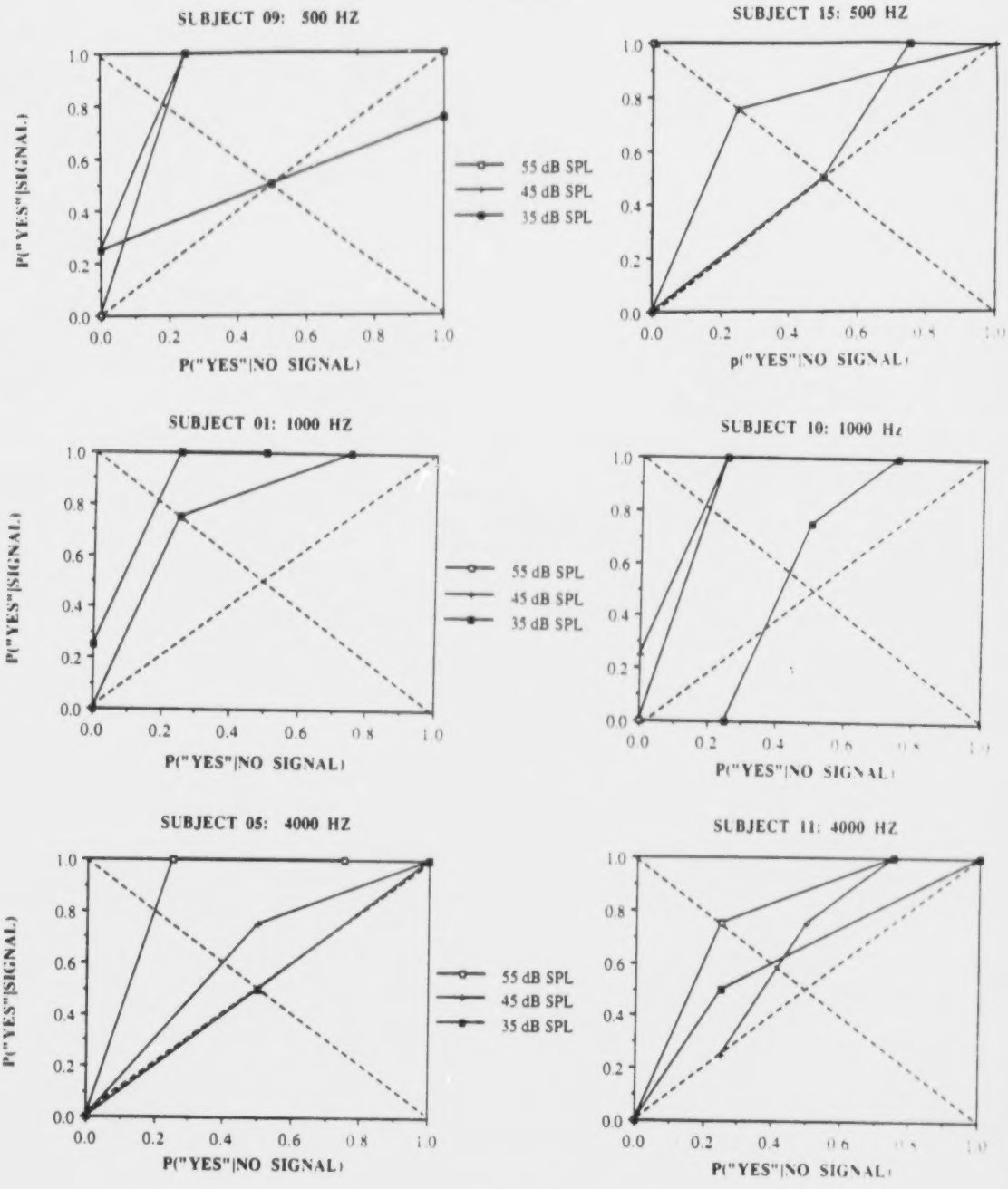






Examples of individual results

ROC curves



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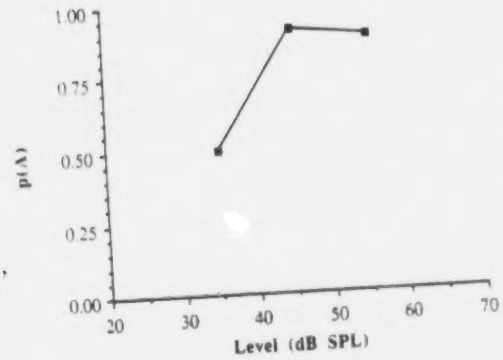
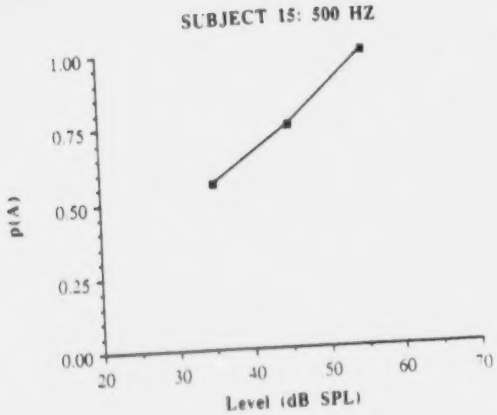
Psychometric functions

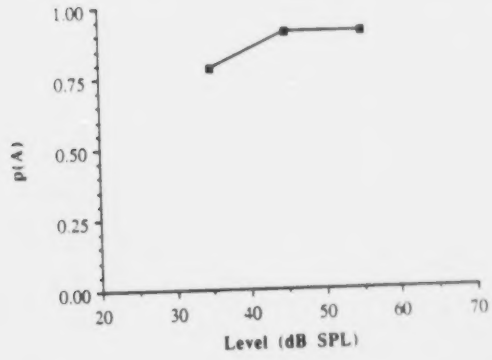
SUBJECT 09: 500 HZ



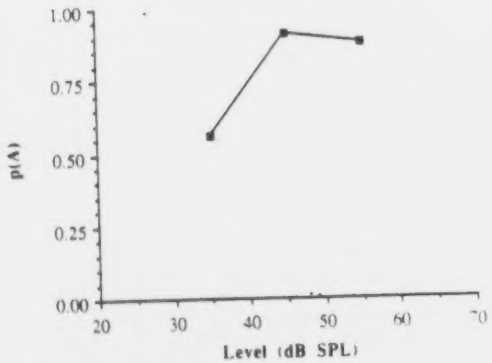
SUBJECT 15: 500 HZ



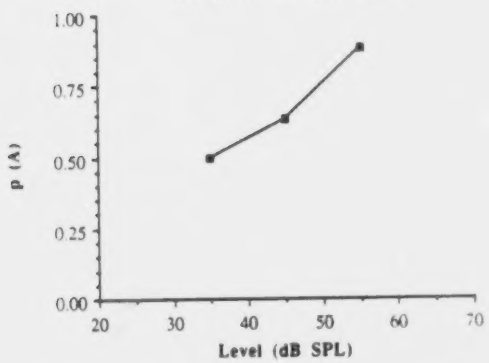
SUBJECT 01: 1000 Hz



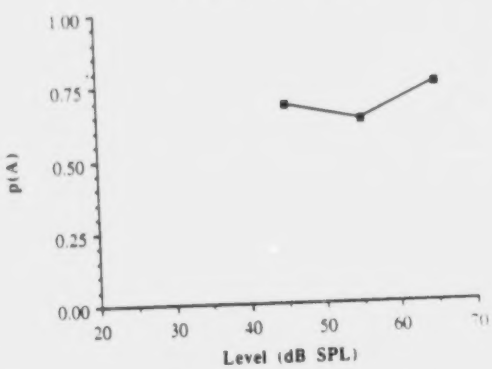
SUBJECT 10: 1000 HZ



SUBJECT 05: 4000 HZ



SUBJECT 11: 4000 HZ



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Conclusions

- Performance of the infant-observer team changes significantly over the course of a test session in an observer-based procedure for assessing hearing, at least for very young infants.

- Changes occur in a frequency-specific manner, although in any case the effect of averaging will be to underestimate infant sensitivity.

- An alternative to a training procedure is to continue testing until performance reaches a plateau or some criterion level.

References

Teller, D. Y., Morse, R., Borton, R., & Regal, D. (1974). Visual acuity for vertical and diagonal gratings in human infants. Vision Research, 14 , 1433-1439.

Trehub, S. E., Schneider, B. A., Thorpe, L. A., & Judge, P. (1991). Observational measures of auditory sensitivity in early infancy. Developmental Psychology, 27, 40-49.

Werner, L. A., & Gillenwater, J. M. (1990). Pure-tone sensitivity of 2- to 5-week-old infants. Infant Behavior & Development, 13, 355-376.